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BRIEF COMMUNICATIONS

MAGNETIC ANISOTROPY OF A MANGANESE CARBONATE ANTIFERROMAGNET

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It is well known from the scientific literature that to estimate the effect of an electric crystalline field on magnetically concentrated crystal anisotropy, an isostructural diamagnetic analog with close lattice parameters is used. The impurity of a magnetic substance sufficient for observation of electron paramagnetic resonance (EPR) spectrum of single ions is introduced into this analog. The constants determined by the EPR methods are then used to describe the energy levels (and hence anisotropy) by solving the equation for a single-ion spin Hamiltonian written in the molecular field approximation for a magnetically concentrated crystal. However, as a rule, it is impossible to find a diamagnetic analog with close enough lattice parameters.

In the present work, the data of EPR investigations of single Mn^{2+} ions in diamagnetic analogs of isostructural $MnCO_3$ [1–4] are generalized and presented in the form of dependences of axial spin Hamiltonian constants D_{cf} and $(a - F)_{cf}$ on the hexagonal lattice constant ratio c_H/a_H (Fig. 1).

The constant $(a - F)_{cf}$ is described by linear plus quadratic dependences on c_H/a_H (signs of constants D_{cf} and $(a - F)_{cf}$ are unknown for $MgCO_3 + Mn^{2+}$ and $ZnCO_3 + Mn^{2+}$ crystals). From these dependences, constants of the spin Hamiltonian for the $MnCO_3$ crystal are determined, and single-ion contribution to the uniaxial anisotropy field $H_{Acf}(0) = 4D_{cf} + (a - F)_{cf}$ is estimated for $T = 0$ K.

A new single-ion exchange mechanism investigated recently in [5–7] can also contribute significantly to the $MnCO_3$ anisotropy. The adequacy of the method used to study this mechanism can be judged only with allowance for all contributions (and, in particular, the single-ion contribution) and subsequent comparison of their sum with an experiment. The method of estimating the single-ion exchange contribution is analogous to the above-described one; the only difference is that EPR is measured for ion pairs. The contribution of manganese carbonate to the uniaxial anisotropy field H_A^{ex} was estimated from the constructed dependences of the single-ion exchange parameters on the lattice constants of isostructural diamagnetic analogs [5].

Table 1 tabulates contributions of the main mechanisms to the uniaxial $MnCO_3$ anisotropy field for $T = 0$ K. Here H_{Adip} is the dipole field contribution, $H_{AT} = H_{Acf} + H_A^{ex} + H_{Adip}$ is the total field estimated theoretically, and H_A is the experimental value of the anisotropy field.

From a comparison of H_{AT} with the experiment it can be seen that the data are in good agreement, which testifies to the adequacy of estimated contributions (see Table 1).

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TABLE 1

$H_{A\mathrm{cf}}$, kOe	$H_{A\mathrm{dip}}$, kOe	H_A^{ex}, kOe	H_{AT}, kOe	H_A, kOe
0.09	3.82 [8]	– 1.04 [5]	2.87	3.01 [9]

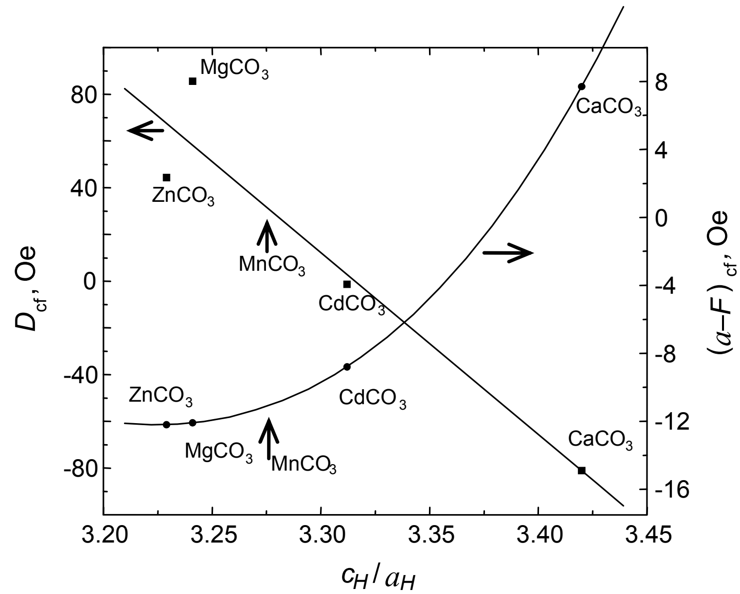

Fig. 1. Dependences of the second- (D_{cf}) and fourth-order axial constants ($(a-F)_{cf}$) of the spin Hamiltonian of the Mn^{2+} ion on the hexagonal cell parameter ratio for rhombohedral diamagnetic crystals. The arrows indicate values corresponding to the magnetically concentrated crystal.

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